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Reducing Diet Digestibility and Increasing Pen Cleaning Frequency: Effects on Nitrogen Losses and Compost Nitrogen Recovery

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Summary

A finishing trial evaluated effects of diet and management on N losses from open feedlots and compost N recovery. Steer calves were fed in 12 pens from November to May. Nitrogen losses from pens were compared by feeding corn bran (30% diet DM) designed to increase OM excretion and by increasing pen cleaning frequency in a 2 x 2 factorial design. Pens were either cleaned monthly or once at the end of the feeding period. Corn bran negatively affected feed/gain by 8.1% and reduced ADG by 4.4%. Dietary treatment and pen cleaning frequency interacted for N balance in the feedlot. Nitrogen losses from pens decreased and manure N increased for steers fed corn bran if pens were cleaned monthly. Corn bran increased the amount of N remaining in composted manure regardless of cleaning frequency. Feeding corn bran and increasing pen cleaning frequency will reduce N losses from open feedlot pens and increase N recovery in compost.

Introduction

As environmental regulations concerning feedlot operations become more stringent, producers will need cost effective alternatives to become and remain compliant with air and water quality regulations. One alternative to reduce N loss is the manipulation of manure carbon to nitrogen (C:N) ratio. The C:N ratio of manure can be altered via dietary manipulations. Previous research at Nebraska has demonstrated feeding corn bran to reduce dietary digestibility reduces N volatilization losses when fed during the winter/spring months (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Another management alternative that may reduce N loss is to clean pens more frequently resulting in less exposure of manure N to surrounding air and subsequent volatilization.

The specific objectives of this research were to: 1) compare the effects of OM addition by feeding less digestible diets on N losses, 2) test the interaction between OM on the pen surface and cleaning frequency on N losses, and 3) determine if increasing pen cleaning frequency of open feedlot pens would decrease N losses from pen surfaces. Our hypothesis is that increasing the C:N ratio of manure by increasing OM excretion will reduce N losses and cleaning pens more frequently may reduce N losses even further.

Procedure

Ninety-six steer calves (741 ± 29 lb BW) were fed 166 days from November to May to evaluate impacts of feeding diets designed to increase OM excretion onto the pen surface and pen cleaning frequency on N balance in open feedlots. Treatments (diet and pen cleaning frequency) were arranged in a 2 x 2 factorial design. Steers were weighed initially on two consecutive days after being limit fed (2% BW) for 5 days to minimize gut fill differences. Steers were stratified by weight and assigned randomly to 12 pens (8 head/pen, 3 pens/treatment).

Two dietary treatments were fed (Table 1). One was designed to mimic a "typical" feedlot diet and was dry-rolled and high moisture corn based (CONTROL). The second was designed to increase OM excretion onto the pen surface (BRAN). In this diet, corn bran replaced dry-rolled corn (30% diet DM) in order to reduce diet digestibility. In addition to diets, two pen cleaning frequency treatments were imposed. Pens were either cleaned monthly or once at the end of the 166 day feeding period. Monthly cleanings consisted of four pen cleanings during the feeding period and one at the end, immediately after steer removal, for a total of five cleanings. Pens cleaned once at the

(Continued on next page)

Table 1. Composition of finishing diets (% DM basis).

Ingredient	CONTROL	BRAN
High moisture corn	45	45
Dry-rolled corn	30	—
Corn bran	—	30
Corn silage	15	15
Molasses	5	5
Supplement[a]	5	5
Urea	0.83	0.61
Feather meal	0.33	0.29
Blood meal	0.04	0.03
Nutrient composition[b]		
CP	12.7	12.8
DIP	7.9	8.9
P	0.32	0.26
K	0.60	0.60
Ca	0.65	0.65

[a]Weighted average of 2 phases of finishing supplements. Supplement provided 28 g/ton Rumensin and 10 g/ton Tylan (90% air-dry basis).
[b]Crude protein was analyzed, other nutrients were calculated; all are expressed as a percentage of diet DM.

end were cleaned immediately after steer removal upon termination of the study.

Adaptation to finishing diets consisted of a 21 day step-up period. Steers initially were implanted with Synovex-S® and re-implanted with Revalor-S® on day 69. Finishing diets were formulated to meet metabolizable protein requirements to minimize excess protein fed above requirements (NRC, 1996). When steers were visually appraised as being finished, they were marketed at a commercial abattoir and carcass data were collected.

Nitrogen balance was conducted in 12 open feedlot pens as previously described (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report; pp. 54-58). Upon completion of the feeding period and during monthly pen cleanings, steers were removed from pens and manure was scraped and piled on the pen surface. As manure was removed from one central pile, manure samples were taken. Manure was weighed on an as-is basis immediately and transported to the University of Nebraska compost yard. Nitrogen intake was quantified by accounting for DMI and N concentration of dietary ingredients, corrected for N content of feed refusals. NRC (1996) net protein and net energy equations were used to calculate steer N retention. Nitrogen excretion (urine plus feces) was determined by difference between N intake and N retention. Manure N was calculated by multiplying manure N concentration by pounds of manure removed (DM) from the pen surface. Soil core N and OM were used to correct manure N and OM for manure left in the pen or soil removed at cleaning. Runoff N was the N concentration of runoff times pounds of water collected. Total N lost was calculated by subtracting soil corrected manure N and runoff N from N excreted. All N values are reported on a pound per steer basis. Percentage of N lost was calculated as N lost divided by N excretion. The manure C:N ratio was calculated by taking the amount of manure OM multiplied by 0.49 (assuming OM contains 49% C) and divided by amount of N in the manure. Organic matter values were all calculated in the same manner as N. Using ash as an internal marker, compost N and OM recoveries were calculated by dividing, N and OM in manure after composting, by N or OM removed from the pen at cleaning.

Performance, carcass and nutrient balance data were analyzed as a completely randomized design with pen as the experimental unit. Model effects were dietary treatment, pen cleaning frequency, and interaction of the two. Least squares means were separated using Least Significant Difference method when a significant ($P < 0.10$) F-test was detected. When a significant dietary treatment x pen cleaning frequency interaction was detected, simple effects are presented. Otherwise, main effects of treatment and pen cleaning frequency are presented.

Table 2. Growth performance and carcass characteristics.

Item	CONTROL	BRAN	SEM	P - value
Initial BW, lb	739	742	2	0.27
DMI, lb	22.9	23.7	0.2	0.01
ADG, lb	3.88	3.71	0.03	<0.01
Feed/gain	5.92	6.40	0.06	<0.01
Hot carcass weight, lb	871	856	3	<0.01
Marbling score[a]	520	501	6.7	0.09
Ribeye area, sq. in.	14.3	14.4	0.2	0.84
12th rib fat, cm	0.49	0.46	0.03	0.57

[a]Marbling score: 450 = Slight^{50}; 500 = Small^{0}; 550 = Small^{50}.

Table 3. Nitrogen mass balance (values expressed as lb/steer).

	Monthly Cleaning		End Cleaning			
Item	CONTROL	BRAN	CONTROL	BRAN	SEM	F-test[a]
N intake	80.2[g]	81.3[g]	76.4[h]	81.8[g]	0.8	0.04
N retention[b]	13.1[g]	12.3[h]	12.4[h]	12.1[h]	0.1	0.08
N excretion[c]	67.1[g]	69.1[g]	64.1[h]	69.7[g]	0.8	0.05
Manure N[d]	35.7[g]	50.6[h]	37.2[g]	35.5[g]	1.7	<0.01
Runoff N	1.15	1.00	1.34	0.88	0.09	0.14
N lost[e]	30.3[gh]	17.4[i]	25.5[h]	33.3[g]	1.8	<0.01
N loss, %[f]	45.1[gh]	25.2[i]	39.8[h]	47.9[g]	2.6	<0.01

[a]P-value for interaction between cleaning frequency and dietary treatment.
[b]Calculated using NRC (1996) net protein and net energy equations.
[c]Calculated as N intake - N retention.
[d]Corrected for soil N concentration before and after trial.
[e]Calculated as N excretion - manure N (corrected for soil) - runoff N.
[f]Calculated as N lost ÷ N excretion.
[g,h,i]Means within a row with different superscripts differ ($P < 0.10$).

Results

No interaction between dietary treatment and pen cleaning frequency occurred for feed conversion; therefore, only effects of dietary treatment on performance are presented (Table 2). Feeding corn bran resulted in a reduction in DMI and ADG, compared to CONTROL ($P < 0.01$). Steers fed BRAN were less efficient ($P < 0.01$) than those fed CONTROL, which is in agreement with previous reports (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Based on steer performance and dietary ingredient composition, corn bran was estimated to have 73% the net energy of DRC when diets contain 45% HMC. Calves fed BRAN had lighter hot carcass weights than those fed CONTROL ($P < 0.01$). Ribeye area and 12th rib fat were not different between dietary treatments; however, marbling scores of steers fed CONTROL were greater than those fed BRAN ($P = 0.09$).

Nitrogen intake and excretion were similar across treatments except calves fed CONTROL with pens cleaned at the end consumed and excreted less total N than the other treatments ($P < 0.05$; Table 3). However, N retention was rela-

Table 4. Manure and compost nutrient composition (values expressed as lb/steer).

Item	Monthly Cleaning		End Cleaning		SEM	P-values[a]		
	CONTROL	BRAN	CONTROL	BRAN		Diet*Clean	Diet	Clean
Manure								
As-is weight removed	3889[de]	5697[f]	3339[d]	4024[e]	260	0.06	<0.01	<0.01
DM, %	64.8	60.6	64.9	52.4	1.8	0.06	<0.01	0.06
DM weight removed	2519[d]	3454[e]	2169[d]	2111[d]	189	0.03	0.05	<0.01
N weight removed[b]	35.7[d]	50.6[e]	37.2[d]	35.5[d]	1.7	<0.01	<0.01	<0.01
OM, %	26.6	29.6	27.8	35.4	3.0	0.47	0.11	0.28
OM removed[c]	739[de]	1200[f]	689[d]	855[e]	60	0.04	<0.01	0.01
C:N ratio	10.1	11.6	9.1	11.8	0.3	0.12	<0.01	0.24
Compost								
N weight[b]	18.0	24.1	15.2	22.4	—	—	—	—
N recovery, %	50.4	47.6	40.9	63.2	—	—	—	—
OM weight[b]	304	385	252	382	—	—	—	—
OM recovery, %	41.1	32.4	36.6	44.7	—	—	—	—

[a]Diet*Clean = interaction between pen cleaning frequency and dietary treatment; Diet = main effect of dietary treatment; Clean = main effect of pen cleaning frequency.
[b]Corrected for soil N concentration before and after trial.
[c]Corrected for soil OM concentration before and after trial.
[d,e,f]Means in a row with different superscripts are different ($P < 0.05$).

tively small when expressed as a percentage of N intake, averaging 16.3 and 15.0% retained N for CONTROL and BRAN, respectively. An interaction occurred between diet and pen cleaning frequency on manure N and N losses from pens. Manure N was greatest with steers fed BRAN and pens cleaned monthly ($P < 0.05$) indicating OM from BRAN along with a more frequent pen cleaning was effective in retaining N. Higher manure N translated into a reduction in N lost when calves were fed BRAN and pens were cleaned monthly. Nitrogen losses were reduced ($P < 0.01$) from 45.1 to 25.2% of N excreted (44% reduction) by feeding BRAN if pens were cleaned monthly. However, if pens were cleaned once at the end, N losses from the pen surface were greater when steers were fed BRAN compared to CONTROL ($P = 0.06$). This was a result of greater N intake and N excretion, yet similar manure N for steers fed BRAN compared to CONTROL. It is not clear why; however, this observation of similar manure N with BRAN feeding contradicts trials with cattle fed during similar times of the year (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Runoff N was not different between treatments and accounted for less than 2% of N excreted. Results indicate more frequent cleaning of pens from steers fed BRAN reduced N losses from feedlot pens as opposed to allowing manure to collect on the pen surface during the entire feeding period. It appears that cleaning feedlot pens more frequently interacts with diet to increase N in manure and reduce N losses.

Effects of diet and pen cleaning frequency on DM, OM and C:N ratios of manure removed are presented in Table 4. Interactions existed between diets and cleaning frequency for the amount of DM and OM removed from pens. The C:N ratio of manure was increased with BRAN feeding regardless of pen cleaning frequency ($P < 0.01$). Feeding BRAN resulted in a higher percentage OM in manure ($P = 0.11$), whereas cleaning frequency did not alter OM percentage in manure. The total amount of OM removed was greater from pens with BRAN fed calves compared to CONTROL because of an increase in excreted manure.

Percentage N recovery in compost was similar between CONTROL and BRAN within monthly pen cleaning frequency (Table 4). However, manure N from BRAN fed calves was higher than CONTROL prior to composting, resulting in a 34% greater total N retention in compost from BRAN fed animals. When pens were cleaned at the end, BRAN compost had a 55% greater N recovery than CONTROL compost, resulting in 47% more N in finished compost although manure N prior to compost was not different. The greater N recovery suggests extra OM excreted from steers fed BRAN was effective in lowering N losses during the composting process. Presumably, the extra OM excretion from corn bran has value in "trapping" more N either in manure or compost.

Feeding corn bran will increase OM on the pen surface, thereby increasing the C:N ratio of feedlot manure. Increasing manure OM removal from the pen surface preserves excreted N and prevents volatile N losses from the pen surface (during the winter/spring months) or from composting. If diets lower in digestibility are fed, performance may be compromised. Cleaning frequency of feedlot pens appears to interact with diet and N losses. Feeding corn bran reduced N losses from pens cleaned monthly. Regardless of cleaning frequency, feeding corn bran resulted in more N retained in composted manure. Reduced N losses from the pen surface and/or composting process will reduce environmental concerns related to N and increase the value of manure when utilized as a crop fertilizer.

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